Physikalisches Institut
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Theoretische Physik

Exercise 7
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SS 06

Exercises on Elementary Particle Physics II

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1. *Gauge invariant couplings*

   A left-chiral superfield ϕ transforms under a U(1) gauge transformation as

   $$\phi \to e^{-2iq\Lambda}\phi$$

   where Λ is a left-chiral superfield and q is the U(1) charge of ϕ. Recall that the vector superfield $V(x, \theta, \bar{\theta})$, which contains the U(1) gauge boson $V_\mu(x)$, transforms as

   $$V \to V' = V + i(\Lambda - \Lambda^\dagger).$$

   (a) Show that $\phi^\dagger e^{2qV}\phi$ is gauge invariant.

   (b) Evaluate the D-term of this expression.
   Hint: Use the Wess-Zumino gauge and the Taylor expansion

   $$e^{2qV} = 1 + 2qV + 2q^2V^2 + \ldots$$

   The result of the first summand (1 + ...) is already known from Ex.4.2.(c).

2. *D-term SUSY breaking- part I*

   Begin with the Lagrangian

   $$\mathcal{L} = \frac{1}{64}\int \mathrm{d}^2\theta \; W^\alpha W_\alpha + \text{h.c.} + \int \mathrm{d}^2\theta \mathrm{d}^2\bar{\theta} \; \left[\phi^\dagger e^{2qV}\phi + 2\xi V\right]$$

   with ξ real, $\phi = (\varphi, \psi, F)$ and q is the charge of ϕ.

   (a) Why is the term $2\xi V$ allowed?

   (b) Solve the equations of motion for the auxiliary field D. What is the scalar potential $V(\varphi)$?

   (c) Discuss the potential $V(\varphi)$ for the two cases: $q\xi < 0$ and $q\xi > 0$. When is SUSY broken? When is the U(1) gauge symmetry broken?